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PREFERENCES OF CONTEXTS FOR LEARNING MATHEMATICS EXPRESSED BY STUDENTS IN RURAL SECONDARY SCHOOL ENVIRONMENTS OF ZIMBABWE

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ABSTRACT

The study aimed at identifying situations for learning Mathematics that could contribute to increasing student motivation for learning that subject in Zimbabwean rural secondary school settings. We asked how student preferences of contexts for learning Mathematics relates to schooling year, Form level and gender in rural secondary school environments. Judgmental and systematic sampling procedures were used to select 450 students from 5 out of about 30 rural secondary schools. Participants consisted of 225 boys and 225 girls all in the 13-17 age range and in their 8th, 9th, and 10th years of schooling. Data were collected by asking the students to express their interest levels in selected contexts for learning using a "Relevance of School Mathematics Education" (ROSME) instrument (Julie, 2005; 2006). Kendall's W mean ranks, medians, modes, clustered bar graphs, and Chi Square were used to describe the trends. The results indicate that learning situations related to science and technology were associated more with boys than with girls, while contexts for learning that have connotations of care-giving were associated more with girls in a rural secondary school setting. The results also suggest that generally higher levels of preferences of contexts for learning can be associated with Form 2 students—who are typically older than their Form 1 counterparts. While these results contradict a literature-based observation that interest with Mathematics diminishes over time (i.e., with age), they probably show that the younger students could be carrying more restricted views of situations deemed to have potential for facilitating development of Mathematical concepts.¹

Introduction

In the Zimbabwean educational system, school Mathematics has attained a filter status and is now a pre-requisite for many academic and professional careers. Although career-oriented factors have been identified as influencing student choice of a favourite subject (Katcher, 2004; Fagan *et al*, 2004), many secondary

¹ Key words:

- Secondary school Mathematics learning;
- motivation for learning;
- gender differentials in Mathematics classrooms;
- contexts for learning Mathematics;
- student preferred learning contexts.

school students display negative attitudes to Mathematics as a subject. Enjoyment (interest or pleasure) has also been cited as a factor influencing student choice of a favourite subject (Fagan *et al*, 2004). However, for students to find Mathematics interesting to them, an important criteria is that the activity of Mathematics learning should “be recognised as a worthwhile activity for the students and this may mean it should make sense in terms of their lives and interests as they genuinely are, and not as teachers or employers or politicians might wish or pretend or imagine” (Orton, 1992: 24). Hence, the issue of increasing students’ motivation for learning Mathematics is an important consideration. There is need for innovative teaching, especially in rural environments in the context of Zimbabwe, so that students can react to Mathematics in the same way they do to music, sport, or art, which they visibly enjoy with intrinsic satisfaction.

This paper reports on a recent study done among secondary school students in a deeply rural district of Zimbabwe to explore the nature of the student’s personal preferences for contexts for learning some mathematical concepts in relation to gender and schooling year level.

Objectives of the study

The objectives of the study were to explore the following:

- the nature of contexts for learning Mathematics that may consequently be effective in engaging students in rural secondary school environments;
- possibilities for making the experience of learning school Mathematics motivating and inspiring to students.

Research Questions

The rationale for the study can be seen as that of a desire to create and promote what Schreiner and Sjoberg (2004) refer to as “broader and more eclectic” ways of thinking about Mathematics in the rural secondary school settings. Consequently, we raised the following research questions:

- How are students’ preferences of contexts for learning Mathematics related to Form level in a rural secondary school environment?
- What gender differences exist in students’ preferences of situations for learning Mathematics content in a rural secondary school setting?

The study focused on student interest levels in Mathematics content as exemplified through various contexts for learning some topics and, hence, has the potential to inform curriculum developers in identifying appropriate and effective situations for developing mathematical ideas during teaching or curriculum construction.

Conceptual Framework

Perceptions on Mathematics

Students develop mental models of the environment and new experiences are interpreted in relation to models the students have already constructed (Johnson-lard, 1983). In particular, students hold their own perceptions about Mathematics content, and contexts for learning are construed in relation to such models about the nature of Mathematics (Kaiser, 1995). These perceptions, in turn, influence their interest levels in situations of learning Mathematics. Some examples of commonly held perceptions are:

- that Mathematics is closely associated with failure and that being bad at Mathematics is acceptable (Wain, 1992);
- that Mathematics is a difficult subject making it natural to dislike it (Ignacio, Nieto, & Barona, 2006: 17);
- that the teacher's responsibility is to provide structure to Mathematics lessons that makes it easy for the students to learn it and for the teachers to explain how to do it (Wain, 1992: 127);
- that the important aspect in learning Mathematics is the obtaining of correct answers only (Orton, 1992: 23);
- that Mathematics can only be mastered by a gifted few (Dörfer, 2007: 106).

While the effect of holding such perceptions on Mathematics might be to make the students experience learning Mathematics a largely passive (rather than active) and non-engaging act, that in turn might have the affective effect of lowering their interest in the subject and then condoning that status of things.

Notion of Context

"Context" is the real scenario or situation in which a mathematical task is encountered by a pupil, which Clarke and Helme (1996) and Kaiser (1995) refer to as the objective figurative context. There is also the subjective figurative context (personalised context), which is an interplay between the social (interactive) and the objective figurative contexts (Clarke & Helme, 1996; Kaiser, 1995). That is to say, a personalised context results from the individual's construal of the objective figurative context. The significance of the notion of context here is that the degree of involvement of the pupil with the situation for learning (objective figurative context) is naturally influenced by the pupil's perception of the nature of Mathematics. This in turn influences the pupil's form of affective response (subjective figurative context) (Clarke & Helme, 1996; Kaiser, 1995). For instance, Flutter and Ruddick in Schreimer and Sjöberg (2004) have reported that students who perceive Mathematics to be a difficult subject display a tendency to dislike it.

Related Studies

The use of social issues as contexts for learning has been advocated by Lovitt and Clarke (1988) who suggest locating Mathematics and Science content in contemporary socio-scientific issues. Some studies on everyday Mathematics contexts for learning have revealed that students who had been exposed to everyday Mathematics contexts tended to learn more Mathematics and to like it better than students exposed to regular programmes (Caroll, 2001; Noyce & Riordan, 2001). Everyday mathematics contexts for learning for rural school students could, for example, be about mathematics to predict crop production, or mathematics for determining the amount of fertilizers to use in specific cropping situations. The use of everyday mathematics contexts for learning is also shared by Clarke and Helme (1996) who propose that contexts for learning should generally be as close as possible to the students' lived life worlds.

In Science, gender has been found to be the most dominant variable for explaining differences in pupil interests (Schreiner & Sjoberg, 2004). The early socialisation process at home has been blamed for creating and fostering the gender differential gap (Taiwo & Molobe, 2004) as girls get "brainwashed" into behaving differently from boys and vice versa. The school further consolidates the atmosphere created by the home through the use of curricular materials that ascribe supportive—and often subordinate—roles (e.g., nursing, teaching, housekeeping) to the feminine gender while depicting males as technocrats such as engineers, miners, accountants, etc. (Taiwo & Molobe, 2004). Consequently, in the differential between sexes, girls have been reported to overwhelmingly demonstrate an interest in care-giving careers in comparison to boys who tend to favour careers such as piloting, building, and engineering.

Another objective of the present study was to find out the relationship between the students' interest levels in mathematics content and Form levels within the population. Age has also been found to be a significant variable in accounting for differences in student interest in science. Interest in school science has been reported to diminish with time or age (Schreiner & Sjoberg, 2004). If we assume that students in a given Form level are older than those in the preceding level (for example, that Form 3s are older than Form 2s), then the study sought to establish whether that observation of interest diminishing with increasing Form level can be substantiated in such a deeply rural population.

Method

Study Context

The research was conducted at 5 rural day secondary schools in one district of Zimbabwe. The word "day" here connotes that such schools do not offer

accommodation facilities to students. Teaching and learning activities take place during day time only. The average distance from the schools to the provincial city is about 100 kilometres. Students walk to school from their homes, the average distance between school and home being about 3 kilometres.

Rural day secondary schools are characterised by inadequate educational provisions such as insufficient textbooks (high textbook-to-student ratio), lack of library or poorly equipped libraries, and low staff retention capacity. For example, in all the five schools visited, all Heads of Departments highlighted the acute shortage of textbooks (in some cases with as many as 8 students sharing a single textbook), and the non-existence of libraries or mathematics laboratories. The teacher is, therefore, the main source of mathematical knowledge in such schools.

Students attending such schools generally work in non-stimulating homework conditions. Brief interviews with students during fieldwork confirmed the non-availability of basic study furniture as students reported that they had no study desks and chairs. Paraffin, the main source of lighting, was not available on the formal market at the time the study was conducted and most parents could not afford the one on the parallel (black) market operating then. Of the 5 schools visited, three had been electrified under the Rural Electrification programme. But only a few students residing in the immediate school environment could study at school at night. The majority of students could not engage in evening study at school owing to long distances between their homes and the school.

Another feature of the rural day secondary schools from which our sample was drawn is low parental involvement in the education of their children. In other communities, schools benefit from parental involvement in the form of material donations such as textbooks, computers, etc. Parents also can offer voluntary academic-related services from retired teachers and related technical support services (e.g., repairing computers). Despite their interest in getting involved, rural parents, the majority of whom are poor peasant farmers, are often constrained by the way they perceive their participation in school activities as some sort of unwanted interference. In addition, such parents were often not good at school and although they want to help, they neither know how they can be of help to their school (Carigan, 2003), nor would they have the confidence to do so.

Because of widespread poverty, most rural day secondary schools cannot afford to employ manual labourers for the general maintenance of the school environment. As a result the learners use part of the available study time at school to devote to "general cleaning" at school. Besides that, students also augment parental labour at home by engaging in activities such as farming—herding cattle and other related domestic duties—as such parents are too poor to engage workers for wages.

Participants

A total of 450 students (225 girls and 225 boys with an age range of 13-17 years) in Forms 1, 2, and 3 drawn from 5 out of about 30 rural secondary day schools in one district of Masvingo province of Zimbabwe were used in the study. A combination of systematic and judgmental (purposive) sampling procedures was used to select 90 students (45 boys and 45 girls) from each school. A total of 30 students per Form level per school (15 boys and 15 girls) was, in turn, selected using random systematic sampling.

In judgmental sampling as defined by Dillon *et al* (1994, p. 62), "respondents are selected because it is expected that they are representatives of the population of interest and/or meet the specific needs of the research study." That kind of selection, in this case, was conducted by one of the authors, and at some of the schools, it was done jointly with the head of the Mathematics department at the school. We first applied the 13-17 age limit constraint to all the students in a particular Form level of interest at the particular school, meaning only students within this age range were allowed to participate in the study. This was done to increase homogeneity by Form level. To bring randomness in the selection process and increase representativeness (Goode & Haat, 1952), systematic sampling was then applied to the sampling frame, i.e., students remaining after effecting the age restriction. At one school, for example, there were 61 boys from 2 class streams of Form 1 made available for random selection after screening for age. They were asked to form a spontaneous queue and we picked every 4th boy in the queue (since 61 divided by 4 gives about 15) yielding 15 boys, and similarly for the girls.

The ROSME instrument

The study used the Relevance of School Mathematics Education (ROSME) questionnaire (Julie, 2005; 2006), an instrument originally designed by researchers at the University of the Western Cape and inspired by the Relevance of Science Education (ROSE) questionnaire instrument (Schreiner & Sjöberg, 2004), but slightly adapted to suit the Zimbabwean rural secondary school context. For instance the cover sheet of the ROSME instrument was slightly modified as part of local face validation of the instrument. And the student background classification item: "I am in grade..." was modified to "I am in form...." The rationale for such adjustments was that in Zimbabwe we use the "Form" at secondary school instead of the "Grade" terminology. The instrument has a main question stem statement that says, "What would you like to learn in mathematics?" The underlying hypothesis was that despite the fact that they may not plan to have mathematical careers, many students may find some aspects of mathematics learning interesting for them (Schreiner & Sjöberg, 2004).

There were 66 items, coded C1 to C66. Items C1 to C62 were closed ended and aimed at exploring students' interest levels in mathematical content in relation to supplied contexts. They all had the same format. C20, for example, read,

"mathematics to prescribe the amount of medicine a sick person must take" with a 4 point Likert scale response categories of "not at all interested"–(rating 1),, "very interested"–(rating 4).

Contexts presented in the items depicted phenomena from a range of occupational activities including agriculture, health, sport, industry, technology, mathematics discipline itself, etc. Items C63 to C65 were of free response type and were meant to give the students an opportunity to articulate their preferred contexts. The last item, C66, enabled the students to construct their mental models of a working mathematician and express them through a sketch diagram.

Thus, the overall thrust of the ROSME instrument was to capture students' thoughts and associations concerning contexts for learning Mathematics, and therefore, provide some empirical evidence on students' interest levels in such contexts for learning. That would in turn give some sense of the relationship between the students' interest levels and Form level, and between gender and preferences of contexts for learning Mathematics, in this case, in a rural secondary school environment.

Validation

The instrument was piloted with a representative sample of 60 students as part of *construct* validation process. This resulted in attending to sensitivities or making adjustments such as the following:

- emphasising that the instrument was an inventory rather than a test during its administration (this was after noting a strong obsession by students for wanting to know their "marks");
- code switching between English and the vernacular, Shona, as necessary throughout the period of administering the instrument to ensure fuller understanding of items by the students (for example, *kutamba makhasa*, was the translation for "gambling");
- simplification of language used, especially technical terms (for instance, replacing "issues" with "things");
- interpreting some terms or expressions in the instrument using local exemplifications (for example, "problems such as those of measuring triangles," for "geometry") that were concrete and, therefore, meaningful to the students, again, to ensure that they understood the intent of the statements more fully.

The main data were gathered from the 5 stratified-randomly selected rural schools within one week towards the end of the school year. The questionnaire took about 45 minutes to complete and was administered in the afternoons during the students' free study time.

Data analysis

Data analysis began with coding each questionnaire by school, gender, Form level, age, and name. A data file was then created using the SPSS package (version 10). The data file had the ROSME data entry format. The data were entered after scanning for clear aberrations such as obvious patterned responses and multiple answers. Further cleaning of the data was done by running simple statistical descriptives to identify any other data-entry type errors. We examined the mean, range, minimum and maximum values of entries using the SPSS Analyse procedure. For example, items with means above 4 and seemingly "unusual" range and extreme values were scanned/checked and corrected. For the data, the possible maximum for any entry was 4 (*very interested*), while the minimum was a 1 (*not at all interested*).

Next, we designated response categories 1 and 2 as negative affect and categories 3 and 4 as positive affect as they captured low and high interest levels respectively (Pallant, 2004). Data elicited from the students were on an ordinal scale level of measurement, hence Kendall's mean ranks, medians, and modes (Pallant, 2004; Puri, 1996) were computed. First, Kendall's W mean ranks and the valid measures of central tendency for ordinal data (mode and median) were calculated for all the 66 closed ended items by Form level and gender using the SPSS package to identify the strongest positive affect (most popular) items and the least preferred (least popular) situations for learning. In addition contexts for learning that revealed pronounced ("real" or significant) differences were also identified. Then the items identified from the above process were subjected to further single-item analysis by means from cross-tabulations.

Cross-tabulations by gender and Form level led to drawing conclusions in relation to the research questions on the basis of:

- Chi-square test considerations to pick up significant associations;
- matching observed and expected frequencies which was done to associate high interest levels or low with a particular value of categorical variable (gender or Form level). For instance from the positive affect class: if for a given value of the categorical variable the observed frequency was greater than the expected frequency, then the value of the variable was associated with high interest level (Puri, 1996);

- clustered bar graphs, which were meant to improve clarity and interpretability of the somehow complex statistical cross tabulations by translating these into simple graphs (Puri, 1996; Kleinbaum & Kupper, 1978; Roberts & Wallis, 1956).

Results

Please note that only three to four items out the total of 66 items on the instrument identified as the most popular through the Kendall's W mean rank statistic were considered for the rest of the analysis discussed in this paper. The remaining items were not of interest for the purposes of this article.

Most and least popular contexts

The Kendall's W test is a nonparametric (appropriate for our ordinal data) which ranks all items from 1 to k where k is the number of items, and then calculates the mean rank for each item (Puri, 1996). Now, for our 62 closed ended items, the maximum mean rank for each item is 62, half of which is 31. Consequently, items with mean ranks above 31 represented positive affect items whilst those with mean ranks below 31 indicated the least preferred contexts for learning Mathematics. The computations of the mean ranks, medians and modes were accomplished by the SPSS Analyse Facility that produced results, some of which are explained below where Table 1 identifies the most popular and least popular contexts

Table 1: Most popular and least popular learning situations

Item	Mode	Median	Kendall's mean rank
C11	4 (<i>very interested</i>)	4 (<i>very interested</i>)	47,6
C3	4 (<i>very interested</i>)	4 (<i>very interested</i>)	43,4
C2	1 (<i>not at all interested</i>)	2 (<i>a bit interested</i>)	19,8

It is noted that the students expressed high preference for C11 (mathematics relevant for professionals such as engineers, lawyers, and accountants) and C3 (mathematics involved in making computer games such as play stations and TV games). These items had means of 47.6 and 43.4 respectively. They both had a mode of 4 and median of 4, confirming their overall popularity. On the other hand, C2 (mathematics for lottery and gambling) with mean 19.8, mode 1, and median 2 (all in the negative affect class), identifies it as the least popular situation for learning Mathematics.

Gender dimension

The 3 items identified above were investigated for variance by gender. Table 2 below shows the results.

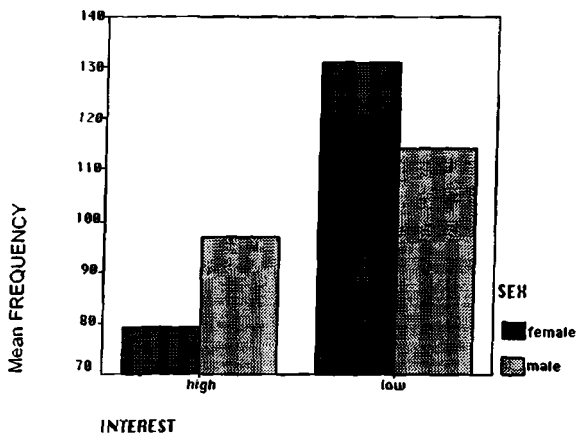
Table 2: Interest levels by gender for items C2 (Mathematics for lottery and gambling), C3 (Mathematics for computer games), and C11 (Mathematics for engineers, lawyers, and accountants)

Item	Males			Females		
	Mode	Median	Kendall's Mean rank	Mode	Median	Kendall's Mean rank
C11	4	4	47.1	4	4	48.0
C3	4	4	43.2	4	4	44.6
C2	1	2	19.4	1	2	20.1

For boys, Kendall's mean ranks for items C11 and C3 are 47.1 and 43.2 respectively. The figures for the girls are 48.0 and 44.6 respectively, again, showing the popularity of the items by gender as well. In contrast C2 had Kendall's mean ranks of 19.4 for boys and 20.1 indicating further that C2 was also the least popular context for learning by the gender dimension. However, the gender differentials were not pronounced for both the most preferred and least preferred contexts for learning.

Pronounced male/female differences were identified in items C19 (mathematics about renewable energy sources such as wind and solar power), and item C20 (mathematics to prescribe the amount of medicine that a sick person must take). These are depicted visually below in Figure 1 and numerically in Table 3.

Figure 1: Gender differences in item C19 (mathematics about renewable energy sources such as wind and solar power)



Clearly, low interest levels in Mathematics related to science, technology, and society [STC] (renewable energy sources) were associated more with girls than boys. That differential was statistically significant at ($p < 0.10$) and one degree of freedom (a 2 by 2 contingency table) with the chi square calculated value of 3.0, way above the critical value of 2.7.

Table 3: Gender difference for Item C20 (mathematics to prescribe the amount of medicine that a sick person must take)

Interest level	Frequency	Female	Male
High	Observed	114	89
	Expected	102.7	100.3
	Percentage	53	42.4
Low	Observed	101	121
	Expected	102.7	109.7
	Percentage	47	57.6
	Total	215	210

From the high interest category it is noted that the male observed frequency is less than the expected frequency while the percentage frequency of girls is higher than that of males—whose observed frequency is less than the expected frequency. All this emphasises the observation that high preferences for such care giving situations can be linked more to the female student. A similar kind of analysis with the entries in the low interest category leads to the same conclusion that high interest in Mathematics involving care-giving situations was associated more with girls (or low interest with boys) in this rural secondary school setting. The gender differential gap noted was statistically significant at ($p < 0.05$) and one degree of freedom (a 2 by 2 contingency table) with the chi square calculated value of 4.8, way above the critical value of 3.3.

Students' interests by Form level

In this section we look at the question of how the students' preferences of contexts for learning Mathematics related to Form level in this rural secondary school environment. The most popular item (C11) and the least popular (C2) were analysed by Form level. This is shown in Table 4 below.

Table 4: Popularity of items C11 (mathematics for engineers, lawyers, and accountants) and C2 (mathematics for lottery and gambling) by Form level

Form	Kendall's mean ranks			Measures of central tendency					
	8	9	10	8		9		10	
Item				Mode	Median	Mode	Median	Mode	Median
C11	47.0	48.2	47.3	4	4	4	4	4	4
C2	18.7	18.1	21.2	1	2	1	1	1	1

With mean ranks of 47.0, 48.2, and 47.3 respectively for Forms 1, 2, and 3; median and mode values of 4 for each Form level, the popularity of item C11 by Form is evident. All the Forms are in the positive affect category. A similar conclusion is also clear by inspection for the negative affect low interest item C2, with mean ranks of 18.7, 18.1, and 21.2; and mode and median values of 1 in all cases except Form 1 with a median value of 2. If, in addition, we match observed and expected frequencies we get more support for the conclusion that associates high interest with Form 2 (middle Form) for item C11 and low interest for item C2. These observations are discussed in the next section.

Discussion

Form level dimension

Literature suggests that interest levels generally diminish with time. It has also been remarked that career-oriented factors do have an impact on student interest in specific subjects (Fagan *et al*, 2004). In this study, however, the middle Form 2 indicated the highest interest levels in C11 (mathematics for engineers, lawyers, and accountants) and the lowest level in C2 (mathematics for lottery and gambling). A plausible explanation for this apparent contradiction with the literature-based observation on C11 is that perhaps Form 1 students had a narrow or restricted view of the context for learning and, thus, it was less appealing to them than it was to Form 2 students (Hoyles, 1992; Wain, 1992). For C2, the reason could be that the older Form 3s have had more exposure than the Form 2s to gambling-like scenarios during their lessons on the topic of probability and statistics, which is introduced in a more explicit fashion in Form 3. Hence, their ignorance of gambling-like activities coupled with the fact that in Zimbabwe the official age for gambling is 18 and society, especially rural society, associates gambling with social misfits and derelicts, may have influenced the younger Form 2 to dislike it more than the older Form 3s.

Gender dimension

One interesting gender related item was that of C51 (mathematics of predicting the sex of a baby) that we could not explain easily. Girls expressed low interest in this item although it has connotations of care-giving. An item that received relatively low interest level ratings by both boys and girls was the one on mathematics to predict crop production and to determine the amount of fertilizers

and chemicals. Although the learning situations would be sort of “everyday” for them, this kind of response seems to suggest that these young students in the rural environment where their parents are mostly peasant farmers, are not inspired by that environment. They may be actually wishing to get out of it. Either way, there are important implications for both mathematics learning or social development drives within those environments.

The most and least popular items [C11 and C2 respectively] were further analysed using Kendall and Lazarsfeld classification of elaboration procedure to check whether the associations detected here were not spurious, that is, they could not be explained away by other related test factors (Goode & Haat, 1952: 356; Mtisi, 2005). That analysis confirmed that the higher levels of interest expressed by boys over girls on item C11 (mathematics for engineers, lawyers, and accountants) could not be explained away by age. For C2 (mathematics for lottery and gambling), however, the lower interest levels expressed by girls more than boys was not spurious for the 13-15 year age range, but was spurious (i.e., could be explained away by age) for the 16-17 year age group. However, this spuriousness could, in turn, be explained by the explicit exposure to the older girls of lottery and gambling situations through the topic of probability theory that is typically introduced in Form 3, as pointed out in the preceding paragraphs.

Conclusion

This study showed that in rural settings such as one where the study was conducted, generally high preferences of some contexts for learning Mathematics could be associated more with Form 2 students than with the older Form 3s in concert with literature. Interestingly, however, other learning contexts showed the reverse trend that contradicts general literature observations. Explanations offered by the authors here for such contradictions lie in the nature of some curricular and socio-economic life orientation or activity of such students within their rural environments. The study also revealed some gender differential depending on the nature of the specific context for learning Mathematics under consideration. High preferences of situations with connotations of care-giving were associated with the female students whereas high interest in science and technology related contexts were generally linked to the male students in the rural secondary school environment. This aspect is in concordance with literature. The gender differential gaps noted in contexts for learning could be reduced, we think, by exposing the male students to more care-giving situations such as nursing or social welfare work activities, for example, through real time visits or enacted drama scripts. Thus, curriculum materials that ascribe male supportive roles need to be considered. Teachers could also expose female students to more science and technology related contexts for learning Mathematics, for instance, through encouraging them to be active in science fairs and clubs. Sensitivity to such considerations by teachers and instructional material developers would be—at the very least—useful.

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